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# UNITED STATES COAL RESOURCES AND PRODUCTION

INTERIM REPORT

JUNE 1971

Conducted in cooperation with the Office of Air Programs, Environmental Protection Agency by the Bureau of Mines under a Working Fund Agreement.

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES
MINERAL SUPPLY

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# UNITED STATES COAL RESOURCES AND PRODUCTION

By Staff

* * * * * * * * * * * * * * * * interim report, June 1971

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

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# UNITED STATES COAL RESOURCES AND PRODUCTION


## ABSTRACT

Data are compiled in this report on the total remaining coal resource of the United States, the production of coal in 1970 by mining method, sulfur content, ash content, and Btu value. Production of all coal has been projected to 1976. Projections have also been made in three sulfur categories: less than 1.0 percent, 1.0 to 2.0 percent, and 2.1 percent or more sulfur.

The total remaining coal resource of the United States, as of December 31, 1970, is estimated at 1,576 billion tons, consisting of 693 billion tons of bituminous coal, 420 billion tons of subbituminous coal, 447 billion tons of lignite, and 16 billion tons of anthracite. All of the subbituminous coal and most of the lignite occurs west of the Mississippi River; 28 percent of the bituminous coal and 3 percent of the anthracite also occurs west of the Mississippi River.

In 1970, 599 million tons of coal was produced in the United States. Sixty-one percent of the production came from underground mines, 36 percent from strip mines, and 3 percent from auger mines. Ninety-two percent of the total production was produced in States east of the Mississippi River. Production from the eastern States accounted for 97 percent of the coal mined underground, 85 percent of the strip-mine coal, and virtually all of the augered coal produced in the Nation.

Projections of coal production by 1976 indicate an increase of about 23 percent for total coal and about 24 percent for coal with 1.0 percent

or less sulfur content. Possible constraints on increasing production include legislation controlling air pollution, the availability of labor, adequacy of transportation, and the new Federal Coal Mine Health and Safety Act of 1969. Technical limitations are also factors that will affect future production.

## INTRODUCTION

As part of a continuing effort to determine the location and extent of fossil fuel resources, this study of the United States coal resource was conducted by the Bureau of Mines with funding provided by the Office of Air Programs, Environmental Protection Agency. This interim report is to define, by State, the coal resource of the Nation and to assess the potential for expanded production in the near future.

Resource and reserve estimates and production reports have been issued by various agencies of the Federal and State governments, and by journals of the coal industry. Many of these reports do not show the current status of the coal resource.

The demand for coal is expected to increase about 23 percent from 1970 to 1976. While the coal resource of the United States is enormous, social and economic constraints may limit the ability of the coal industry to maintain its position in the energy market. Coal quality is now of prime importance as opposed to the basic consideration of heat value that prevailed until recent years. The sulfur content of coal, a source of air pollution, is a factor that will affect the future

production and end-use of many coal deposits. Legislative restrictions on sulfur emissions will be a constraint on future coal production unless the sulfur can be adequately reduced by pre- or post-combustion cleaning. In addition to environmental considerations, the availability of skilled miners and of transportation facilities will also influence the industry's ability to meet the Nation's probable need for coal.

This is an interim report on United States coal resources and production. It is prepared by the Bureau of Mines in cooperation with the Office of Air Programs, Environmental Protection Agency, under a working fund agreement. Under this same working fund agreement, a final report on the United States coal resources and production is being prepared in more detail and will include coal quality, ownership, marketing, and other elements important to the coal industry. Also under this working fund agreement, a report "Analysis of the Availability of Bituminous Coal in the Appalachian Region" has been completed.

## UNITED STATES COAL RESOURCE

Data on the estimated original coal, estimated remaining coal, production, and mining loss were compiled from published sources. The total remaining coal resource is estimated at 1,576 billion tons (tables 1-4).

The estimated original coal resource and the estimated remaining coal is the gross resource in the ground, based on the minimum seam thickness and maximum depth. Fifty percent, or about 788 billion tons

TABLE 1. - Bituminous coal resources of the United States

(Million tons)

| State | Criteria 1/ | | Original estimate of coal in the ground | Source of original estimate 2/ | Total production to Dec.31, 1970 | Estimated loss due to mining to Dec.31, 1970 | Estimated coal remaining in ground Dec.31, 1970 | Estimated remaining reserves on Jan.1, 1965 (I.C.8312) |
|---|---|---|---|---|---|---|---|---|
| | Minimum seam thickness in inches | Maximum overburden depth in feet | | | | | | |
| Alabama | 14 | 3,000 | 15,669 | (1) | 1,110 | 1,110 | 13,449 | 13,557.8 |
| Alaska | 14 | 3,000 | 19,429 | (2,54) | 8 | 8 | 19,413 | 21,387.4 |
| Arizona | None | None | 11,660 | (4) | --- | --- | 11,660 | (3) |
| Arkansas | 14 | 3,000 | 2,272 | (5) | 101 | 101 | 2,070 | 1,615.8 |
| California | None | None | 10 | (6) | --- | --- | 10 | (3) |
| Colorado | 14 | 3,000 | 63,203 | (7,8) | 429 | 429 | 62,345 | 62,415.5 |
| Georgia | --- | --- | --- | --- | --- | --- | --- | 76.0 |
| Idaho | 14 | 2,000 | 9 | (9,10) | --- | --- | 9 | (3) |
| Illinois | 18 | 3,000 | 156,097 | (11) | 4,232 | 4,231 | 147,634 | 135,889.2 |
| Indiana | 14 | 1,000 | 37,293 | (12,54) | 1,337 | 1,337 | 34,619 | 34,841.1 |
| Iowa | 14 | 1,000 | 7,237 | (14,54) | 363 | 362 | 6,512 | 6,522.5 |
| Kansas | 14 | 1,200 | 19,002 | (15) | 292 | 73 | 18,637 | 20,738.0 |
| Kentucky | 14 | 1,000 | 72,318 | (16) | 3,615 | 3,614 | 65,089 | 66,310.2 |
| Maryland | 14 | 3,000 | 1,727 | (54) | 279 | 279 | 1,169 | 1,180.0 |
| Michigan | 14 | 3,000 | 297 | (17,54) | 46 | 46 | 205 | 205.0 |
| Missouri | 14 | 3,000 | 31,670 | (18) | 322 | 322 | 31,026 | 78,760.0 |
| Montana | 14 | 3,000 | 2,363 | (19) | 33 | 33 | 2,297 | 2,104.6 |
| New Mexico | 14 | 3,000 | 10,948 | (20) | 107 | 107 | 10,734 | 10,686.0 |
| North Carolina | --- | --- | --- | --- | --- | --- | --- | 110.0 |
| Ohio | 14 | 1,000 | 46,488 | (22,54) | 2,512 | 2,511 | 41,465 | 42,024.0 |
| Oklahoma | 14 | 3,000 | 3,563 | (23) | 193 | 193 | 3,177 | 3,302.8 |
| Oregon | 14 | 1,500 | 50 | (24-27) | 2 | 1 | 47 | 14.0 |
| Pennsylvania | 18 | 1,000 | 75,093 | (28,54) | 9,048 | 9,047 | 56,998 | 57,951.5 |
| Tennessee | 14 | 1,000 | 2,748 | (32,54) | 463 | 462 | 1,823 | 1,839.5 |
| Texas | 14 | 3,000 | 6,065 | (33,34) | 24 | 24 | 6,017 | 7,978.0 |
| Utah | 14 | 3,000 | 32,121 | (35-45) | 306 | 305 | 31,510 | 27,658.0 |
| Virginia | 14 | 1,000 | 11,696 | (46,54) | 1,158 | 1,157 | 9,381 | 9,820.0 |
| Washington | 14 | 3,000 | 1,869 | (47,49) | 1 | 1 | 1,867 | 1,571.0 |

TABLE 1. - Bituminous coal resources of the United States - Continued

(Million tons)

| State | Criteria 1/ | | Original estimate of coal in the ground | Source of original estimate 2/ | Total production to Dec.31, 1970 | Estimated loss due to mining to Dec.31, 1970 | Estimated coal remaining in ground Dec.31, 1970 | Estimated remaining reserves on Jan.1, 1965 (I.C.8312) |
|---|---|---|---|---|---|---|---|---|
| | Minimum seam thickness in inches | Maximum overburden depth in feet | | | | | | |
| West Virginia | 12 | --- | 116,618 | (50,54) | 7,856 | 7,855 | 100,907 | 102,666.4 |
| Wyoming | 14 | 3,000 | 13,235 | (51-53) | 286 | 286 | 12,663 | 12,819.9 |
| Other States 4/ | --- | --- | --- | --- | --- | --- | --- | 616.0 |
| Totals | | | 760,750 | | 34,123 | 33,894 | 692,733 | 724,680.2 |

1/ Minimum seam thickness and maximum overburden depth are the limits used in computing original estimate of coal resource as given in the reference.
2/ Underlined numbers in parentheses refer to the numbered references at the end of this report.
3/ Included with other States, I.C. 8312.
4/ Includes Arizona, California, Idaho, Nebraska, and Nevada.

TABLE 2. - Subbituminous coal resources of the United States

(Million tons)

| State | Criteria: Minimum seam thickness in inches | Criteria: Maximum overburden depth in feet | Original estimate of coal in the ground | Source of original estimate 1/ | Total production to Dec.31, 1970 | Estimated loss due to mining to Dec.31, 1970 | Estimated coal remaining in ground Dec.31, 1970 | Estimated remaining reserves on Jan.1, 1965 (I.C. 8312) |
|---|---|---|---|---|---|---|---|---|
| Alaska 2/ | 30 | 3,000 | 110,696 | (2,54) | 13 | 12 | 110,671 | 71,115.6 |
| Arizona | (3) | (3) | 9,625 | (4) | --- | --- | 9,625 | (4) |
| California | (3) | (3) | 40 | (6) | --- | --- | 40 | (4) |
| Colorado | 30 | 3,000 | 18,492 | (7,8) | 129 | 129 | 18,234 | 18,229.5 |
| Montana | 30 | 3,000 | 132,151 | (19) | 140 | 140 | 131,871 | 132,116.6 |
| New Mexico | 30 | 3,000 | 50,801 | (20) | 49 | 49 | 50,703 | 50,735.0 |
| Oregon | 30 | 1,500 | 66 | (24) | 3 | 2 | 61 | 174.0 |
| Utah | 30 | 3,000 | 156 | (35-45 incl) | 3 | 3 | 150 | 150.0 |
| Washington | 30 | 3,000 | 4,194 | (47-49 incl) | --- | --- | 4,194 | 4,193.8 |
| Wyoming | 30 | 3,000 | 94,583 | (51-53 incl) | 154 | 154 | 94,275 | 107,903.9 |
| Other States 5/ | --- | --- | --- | --- | --- | --- | --- | 4,047.0 |
| Totals | | | 420,804 | | 491 | 489 | 419,824 | 388,665.4 |

1/ Underlined numbers in parentheses refer to numbered items in the list of references at the end of this report.
2/ Includes lignite.
3/ Gross estimate, no limits set.
4/ Included in other States, I.C. 8312.
5/ Arizona, California, Idaho.

TABLE 3. - Lignite resources of the United States

(Million tons)

| State | Criteria: Minimum seam thickness in inches | Criteria: Maximum overburden depth in feet | Original estimate of lignite in the ground | Source of original estimate 1/ | Total production to Dec.31, 1970 | Estimated loss due to mining to Dec.31, 1970 | Estimated lignite remaining in ground Dec.31, 1970 | Estimated remaining reserves on Jan.1, 1965 (I.C.8312) |
|---|---|---|---|---|---|---|---|---|
| Alabama | --- | --- | 20 | (1,54) | --- | --- | 20 | 20.0 |
| Arkansas | 30 | 100 | 32 | (5) | --- | --- | 32 | 350.0 |
| California | (2) | (2) | 50 | (6) | --- | --- | 50 | (3) |
| Montana | 30 | 2,000 | 87,533 | (19) | 4 | 1 | 87,528 | 87,481.7 |
| North Dakota | 30 | 1,200 | 350,910 | (21) | 131 | 26 | 350,753 | 350,698.0 |
| South Dakota | 30 | 1,000 | 2,033 | (31) | 1 | --- | 2,032 | 2,031.0 |
| Texas | 60 | 500 | 7,070 | (33,34) | 47 | 10 | 7,013 | 6,902.0 |
| Washington | 60 | 1,000 | 117 | (47-49 incl) | --- | --- | 117 | 116.6 |
| Other States 4/ | --- | --- | --- | --- | --- | --- | --- | 42.0 |
| Totals | | | 447,765 | | 183 | 37 | 447,545 | 447,641.3 |

1/ Underlined numbers in parentheses refer to numbered items in the list of references at the end of this report.
2/ Gross estimate, no limits set.
3/ Included in other States, I.C. 8312.
4/ California, Idaho, Louisiana, Nevada.

TABLE 4. - Anthracite resources of the United States

(Million tons)

| State and County | Criteria: Minimum seam thickness in inches | Criteria: Maximum overburden depth in feet | Original estimate of anthracite in the ground | Source of original estimate 1/ | Total production to Dec.31, 1970 | Estimated loss due to mining to Dec.31, 1970 | Estimated anthracite remaining in ground Dec.31, 1970 |
|---|---|---|---|---|---|---|---|
| Arkansas | 14 | 3,000 | 456 | (5) | 13 | 13 | 430 |
| Colorado | 14 | 3,000 | 90 | (7) | 6 | 6 | 78 |
| New Mexico | 14 | 3,000 | 6 | (20) | 1 | 1 | 4 |
| Pennsylvania | 24 | 3,000 | 22,805 | (54) | 5,179 | 2,769 | 14,857 |
| County: | | | | | | | |
| Carbon | | | 630 | | 194 | 122 | 314 |
| Columbia | | | 615 | | 85 | 46 | 484 |
| Dauphin | | | 180 | | 62 | 72 | 46 |
| Lackawanna | | | 2,030 | | 1,085 | 570 | 375 |
| Lebanon | | | 35 | | --- | --- | 35 |
| Luzerne | | | 4,525 | | 2,026 | 758 | 1,741 |
| Northumberland | | | 2,600 | | 445 | 226 | 1,929 |
| Schuylkill | | | 12,130 | | 1,357 | 964 | 9,909 |
| Sullivan | | | 35 | | 18 | 8 | 9 |
| Susquehanna | | | 15 | | 7 | 3 | 5 |
| Wayne | | | 10 | | --- | --- | 10 |
| Virginia | 14 | 3,000 | 355 | (46) | 10 | 10 | 335 |
| Washington | 14 | 3,000 | 5 | (47,48) | --- | --- | 5 |
| Totals | | | 23,717 | | 5,209 | 2,799 | 15,709 |

1/ Underlined numbers in parentheses refer to numbered items in the list of references at the end of this report.

of the remaining resource, is unminable because seams are too thin, too deep, or underlie surface features which preclude mining. Of the 50 percent considered available for mining, only about 542 billion tons will actually be recovered. This is based on the assumed recovery of 57 percent by underground mining, and 80 percent recovery by strip mining. Thus, only about 34 percent of the estimated remaining coal as of December 31, 1970, should be considered recoverable.

## Bituminous Coal

Of the estimated 693 billion tons of remaining bituminous coal resource (table 1), about 204 billion tons may be physically recovered. Illinois has the largest remaining resource, followed by West Virginia and Kentucky. The greatest cumulative production to December 31, 1970, came from Pennsylvania, West Virginia, and Illinois, in that order. A little over two-thirds (68 percent) of the reserves are situated east of the Mississippi River and 32 percent west of the River.

## Subbituminous Coal

All of the subbituminous coal resource is located in 10 western States and Alaska (table 2). Current production is almost entirely by strip mining. Of the 420 billion tons of coal remaining, about 156 billion tons may be recovered. Montana has the largest remaining subbituminous coal resource followed by Alaska and Wyoming.

## Lignite

Lignite deposits occur in 11 States with the major deposits located in a large basin covering eastern Montana, western North Dakota, and northwestern South Dakota (table 3 and fig. 1). Current production is all from strip mining. Of the 447 billion tons of remaining resource, an estimated 179 billion tons may be recoverable. North Dakota has 78 percent and Montana 20 percent of the remaining resource. North Dakota produced 72 percent of the 183 million tons of total cumulative lignite production in the United States to December 31, 1970 (table 3).

## Anthracite

Of the 16 billion tons of remaining anthracite resource in the United States, 15 billion tons or 95 percent is located in Pennsylvania (table 4). About 5 billion tons of this resource might be physically recovered, but it is conservatively estimated that economic recovery may be as low as 3 billion tons because much of the anthracite is submerged below the water table. From 20 to 30 tons of water must be pumped in order to produce 1 ton of deep-mined anthracite. Current production and most of the future production will most probably come from Pennsylvania deposits.

The resource shown for Pennsylvania (table 4) does not include that anthracite recoverable from culm banks or river dredging as those sources are included in mining losses due to past production. The largest remaining resource is in Schuylkill County, followed by Northumberland and Luzerne Counties. However, the greatest production has been from Luzerne, Schuylkill, and Lackawanna Counties.

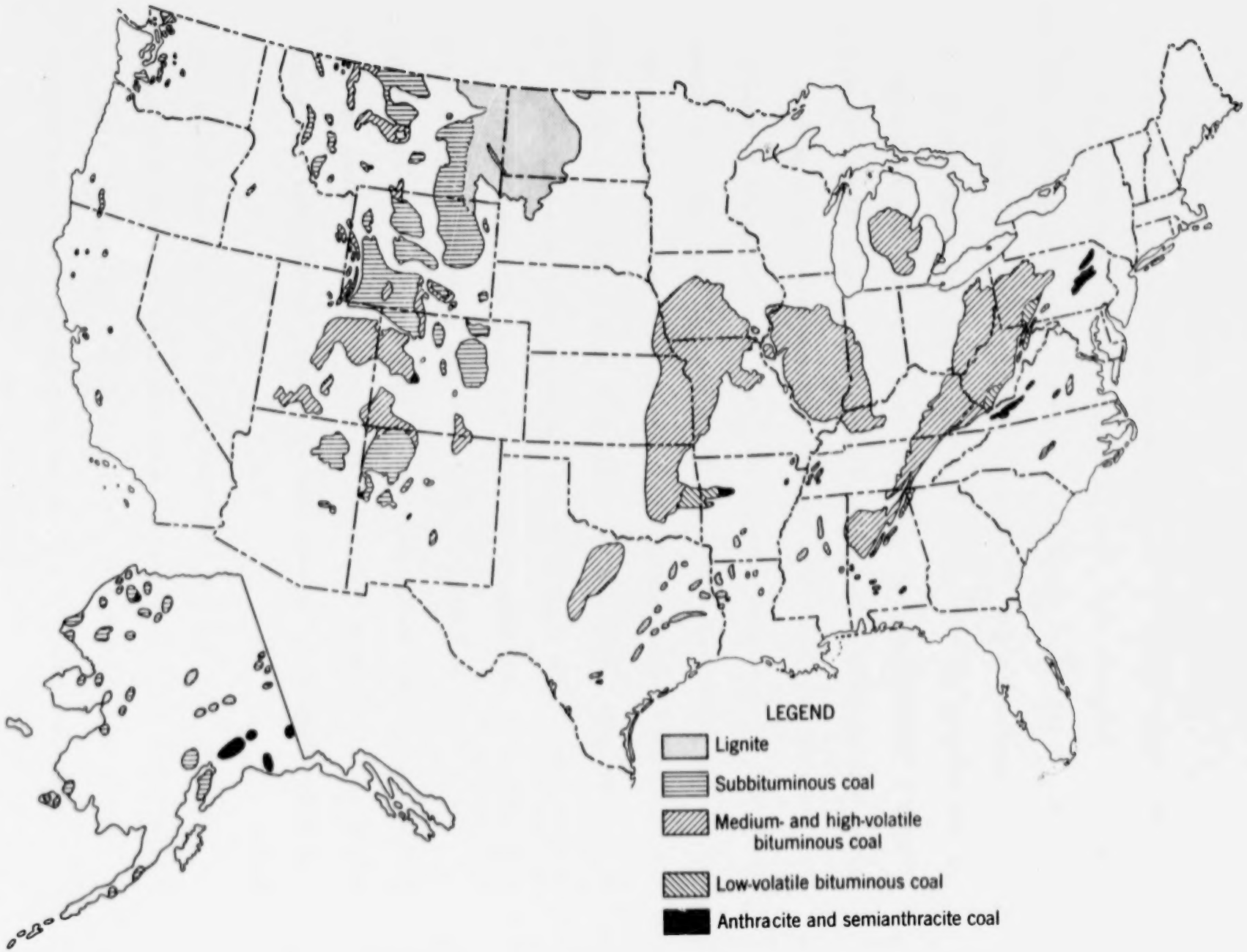



FIGURE 1. - Coalfields of the United States

## COAL PRODUCTION AND CONSUMPTION

Coal is produced by three mining methods, deep (underground), strip (surface), and augering. Deep mining is the most costly per ton of coal produced, followed by strip mining, and by auger mining which costs the least. In general, the larger a mining operation, the lower the cost per ton of coal produced. A study of figure 2 and table 5 shows that from 1958 through 1969 the numbers of the different types of mines varied individually with little relationship to each other. However, over the same period of time the production curves bear a marked similarity to each other (fig. 3 and table 6). In figure 4 (tables 5 and 6), the percentage curves for the number of deep and strip mines show a converse relationship - the same as with deep and auger. The production from deep and strip mines also show a converse relationship to each other. The same curve for the auger mines shows little relationship to the respective curves for deep and strip mining.

The curves for number of deep and strip mines and deep and strip production indicate that production is more a function of mine capacity rather than the number of mines. The curves for auger mines indicate that auger production is more closely related to the number of auger mines.

The year 1967 was the year that production costs approached the selling price for the commercial coal companies and production dropped in 1968 for all three types of mining (table 6 and fig. 3). The decrease in the number of deep mines continued while strip and auger

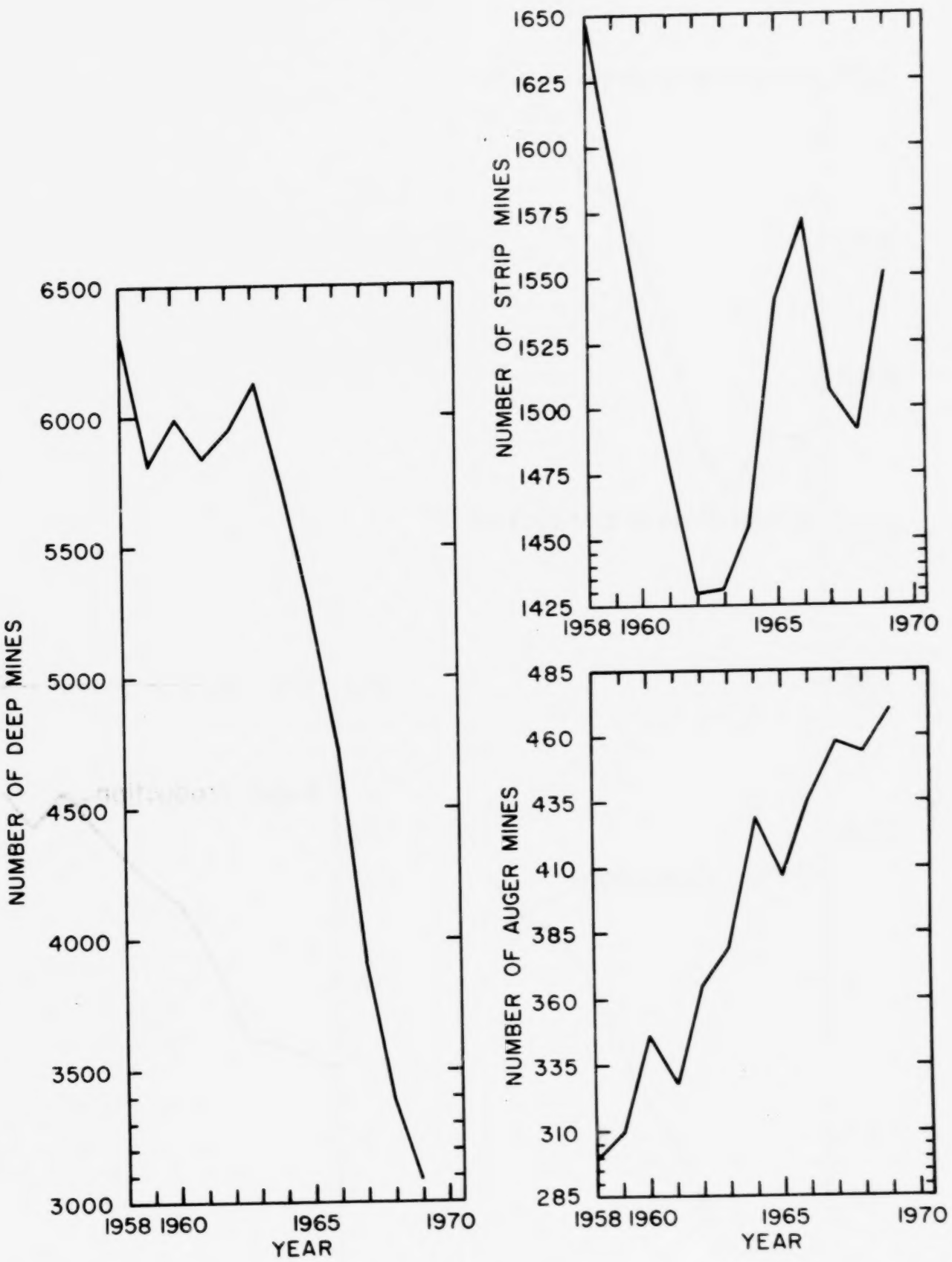



FIGURE 2. - Number of mines by mining method, 1958-1969.

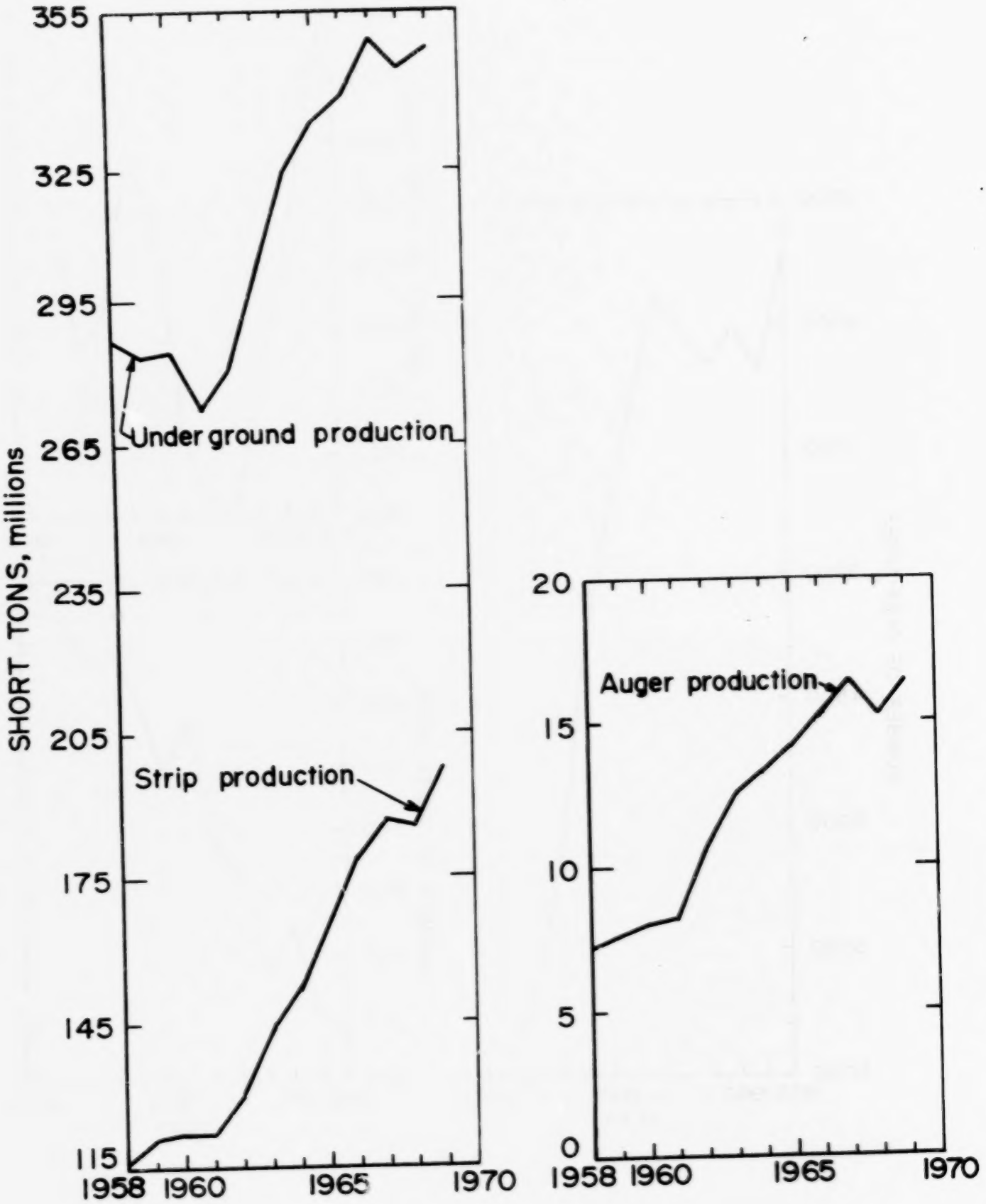



FIGURE 3. - Coal production in the United States, by mining method, 1958-1969.

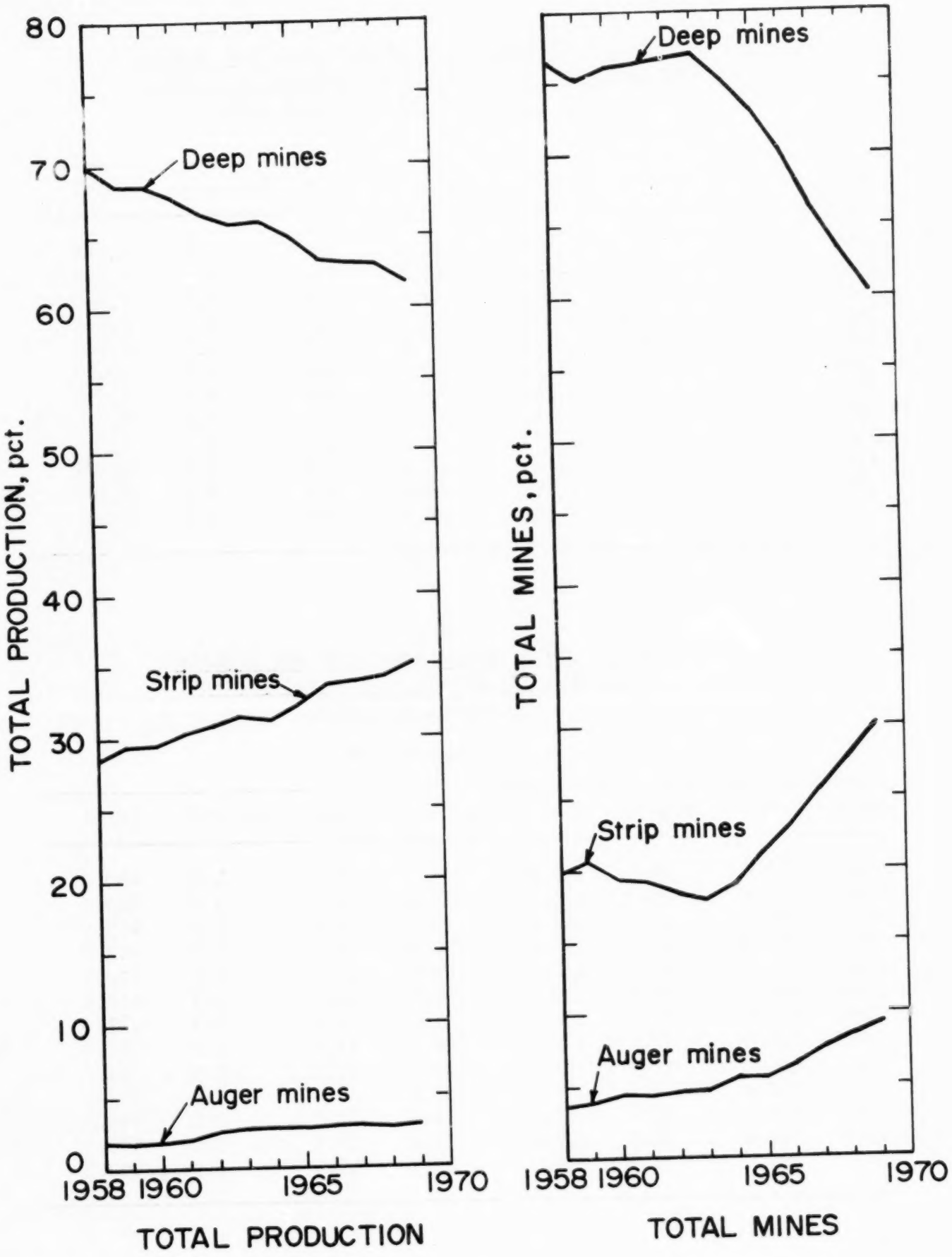



FIGURE 4. - Percent of total production and total mines, by mining method, 1958-1969.

TABLE 5. - Number of operating bituminous coal and lignite mines, by mining method and percent of total, 1958-1969, in the United States

| Year | Deep | Percent | Strip | Percent | Auger | Percent | Total |
|---|---|---|---|---|---|---|---|
| 1958 | 6,319 | 76.5 | 1,646 | 19.9 | 299 | 3.6 | 8,264 |
| 1959 | 5,815 | 75.3 | 1,594 | 20.7 | 310 | 4.0 | 7,719 |
| 1960 | 5,989 | 76.1 | 1,530 | 19.5 | 346 | 4.4 | 7,865 |
| 1961 | 5,843 | 76.4 | 1,477 | 19.3 | 328 | 4.3 | 7,648 |
| 1962 | 5,946 | 76.8 | 1,429 | 18.5 | 365 | 4.7 | 7,740 |
| 1963 | 6,129 | 77.2 | 1,431 | 18.0 | 380 | 4.8 | 7,940 |
| 1964 | 5,746 | 75.3 | 1,455 | 19.1 | 429 | 5.6 | 7,630 |
| 1965 | 5,280 | 73.1 | 1,541 | 21.3 | 407 | 5.6 | 7,228 |
| 1966 | 4,741 | 70.2 | 1,572 | 23.3 | 436 | 6.5 | 6,749 |
| 1967 | 3,908 | 66.5 | 1,507 | 25.7 | 458 | 7.8 | 5,873 |
| 1968 | 3,381 | 63.5 | 1,492 | 28.0 | 454 | 8.5 | 5,327 |
| 1969 | 3,097 | 60.5 | 1,551 | 30.3 | 470 | 9.2 | 5,118 |

TABLE 6. - United States bituminous coal and lignite production by mining method and percent of total, 1958-1970

(Million tons)

| Year | Deep | Percent | Strip | Percent | Auger | Percent | Total |
|---|---|---|---|---|---|---|---|
| 1958 | 286.9 | 69.9 | 116.2 | 28.3 | 7.3 | 1.8 | 410.0 |
| 1959 | 283.4 | 68.8 | 121.0 | 29.4 | 7.6 | 1.8 | 412.0 |
| 1960 | 284.9 | 68.6 | 122.6 | 29.5 | 8.0 | 1.9 | 415.5 |
| 1961 | 272.8 | 67.7 | 122.0 | 30.3 | 8.2 | 2.0 | 403.0 |
| 1962 | 281.3 | 66.6 | 130.3 | 30.9 | 10.6 | 2.5 | 422.2 |
| 1963 | 302.3 | 65.9 | 144.1 | 31.4 | 12.5 | 2.7 | 458.9 |
| 1964 | 321.8 | 66.1 | 151.9 | 31.2 | 13.3 | 2.7 | 487.0 |
| 1965 | 332.7 | 65.0 | 165.2 | 32.3 | 14.2 | 2.7 | 512.1 |
| 1966 | 338.5 | 63.4 | 180.1 | 33.7 | 15.3 | 2.9 | 533.9 |
| 1967 | 349.1 | 63.2 | 187.1 | 33.9 | 16.4 | 2.9 | 552.6 |
| 1968 | 344.1 | 63.1 | 185.8 | 34.1 | 15.3 | 2.8 | 545.2 |
| 1969 | 347.1 | 61.9 | 197.0 | 35.1 | 16.4 | 3.0 | 560.5 |
| 1970 | 362.4 | 61.4 | 210.5 | 35.7 | 17.4 | 2.9 | p/590.3 |

p/ Preliminary.

mining increased. An increase in coal prices toward the end of 1967 resulted in an appreciable upturn in 1969 in all production and in the number of strip and auger mines while the number of deep mines continued to decrease.

## Bituminous Coal and Lignite

Nearly all of the Nation's coal production in 1970 (93 percent) came from States east of the Mississippi River (tables 7 and 9, fig. 5). Of the bituminous coal and lignite production in 1970, 97 percent of the deep mine production, 86 percent of the strip mine production and virtually all of the auger mine production was mined east of the Mississippi River. All of the lignite production, about 8 million tons, was produced west of the Mississippi River in North Dakota and Texas. All the lignite was strip mined.

In the Appalachian Region, bituminous coalbeds vary from flat-lying to moderately folded. The seams range in thickness from a few inches up to 9 feet. They are mined in thicknesses from 14 inches up and mined at depths down to about 1,300 feet. Coal seams are continuous over large areas and can be correlated over comparatively great distances and from one State to another even though the name may change from area to area or from State to State. The production ratio of deep-mined coal to strip-mined coal is the highest in the Nation, 3.1 to 1.

Bituminous coalbeds in the Michigan basin or Northern Region of the Interior Province are mostly at depths below the water table and cannot be mined competitively at this time. Consequently, there is no recent production and none is expected prior to 1976.

TABLE 7. - Bituminous coal and lignite production in the United States in 1970, by State and type of mining (preliminary)

(Million tons)

| State | Deep mines | Strip mines | Auger mines | Total |
|---|---|---|---|---|
| Alabama | 10.37 | 9.09 | 0.04 | 19.50 |
| Alaska | --- | 0.83 | --- | 0.83 |
| Arizona | --- | 0.28 | --- | 0.28 |
| Arkansas | 0.10 | 0.28 | --- | 0.38 |
| Colorado | 3.81 | 2.02 | --- | 5.83 |
| Idaho | --- | --- | --- | --- |
| Illinois | 30.10 | 34.63 | --- | 64.73 |
| Indiana | 2.21 | 18.79 | --- | 21.00 |
| Iowa | 0.44 | 0.63 | --- | 1.06 |
| Kansas | --- | 2.03 | --- | 2.03 |
| Kentucky, East | 49.86 | 11.04 | 8.07 | 68.97 |
| Kentucky, West | 22.22 | 30.93 | 0.01 | 53.16 |
| Maryland | 0.41 | 1.24 | 0.11 | 1.76 |
| Michigan | --- | --- | --- | --- |
| Missouri | --- | 2.80 | --- | 2.80 |
| Montana | 0.06 | 1.68 | --- | 1.74 |
| New Mexico | 1.05 | 4.55 | --- | 5.60 |
| North Dakota | --- | 4.90 | --- | 4.90 |
| Ohio | 18.73 | 31.21 | 1.65 | 51.59 |
| Oklahoma | 0.17 | 2.35 | --- | 2.52 |
| Oregon | --- | --- | --- | --- |
| Pennsylvania | 57.95 | 22.68 | 0.65 | 81.28 |
| Tennessee | 4.94 | 3.73 | 0.27 | 8.94 |
| Utah | 4.85 | --- | --- | 4.85 |
| Virginia | 33.59 | 3.93 | 1.81 | 39.33 |
| Washington | 0.06 | (1) | --- | 0.06 |
| West Virginia | 121.26 | 14.47 | 4.78 | 140.51 |
| Wyoming | 0.18 | 6.45 | --- | 6.63 |
| Total | p/362.36 | p/210.55 | p/17.38 | p/590.29 |

p/ Preliminary.
1/ Not significant.

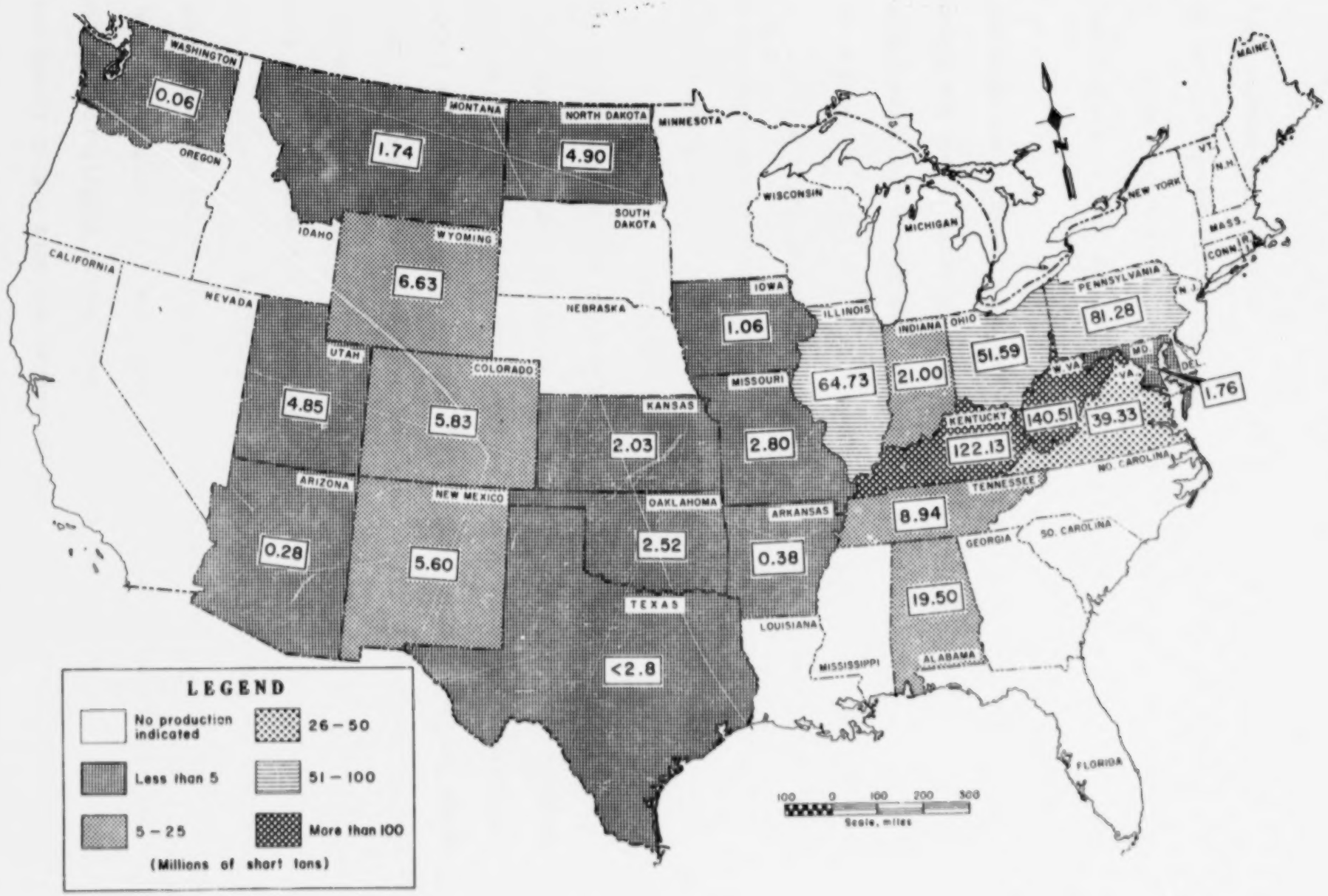



FIGURE 5. - Production of bituminous coal and lignite, by State, 1970

The bituminous coalbeds of Illinois, Indiana, and western Kentucky are located in the Eastern Region of the Interior Province. The seams are essentially flat-lying with a gentle dip toward the center of the coal basin. The production ratio of deep-mined coal to strip-mined is about 0.6 to 1.

The coalbeds in Arkansas, Iowa, Kansas, Missouri, and Oklahoma are in the Western Region of the Interior Province. They are generally flat-lying bituminous seams with about 7 percent of the recoverable reserves at depths that can be strip mined. In 1970, 92 percent of the total production from this region was produced by strip mining.

There was no production of bituminous coal from the Southern Region of this Province in Texas. However, there was a small production of lignite in the Texas part of the Gulf Province.

Production of coal in the Northern Great Plains Province in 1970 included bituminous and subbituminous coals and lignite. Lignite, occurring in eastern Montana, western North Dakota, and northwestern South Dakota was mined only in Montana and North Dakota. The total production of about 7 million tons was produced by strip mining. The bituminous and subbituminous coals produced in this province cannot be readily separated from the coals produced in the Rocky Mountain Province and must be included with production therefrom.

The bituminous and subbituminous coalbeds of the Northern Great Plains and Rocky Mountain Provinces vary from flat-lying to steeply dipping. In general, the shallower, more gently dipping to flat deposits are subbituminous in rank, and the deeper and more highly folded beds are bituminous in rank. Coal seams range from a few inches up to 100

feet thick in the Powder River basin of Montana and Wyoming, and many beds have thicknesses up to 30 feet. Many beds tend to be lenticular and may thin rapidly. Regional correlation of seams is virtually non-existent. Production is by deep and strip mining with a production ratio of deep to strip mining of 0.6 to 1. There is as yet no auger mine production in these provinces.

The Pacific Coast Province which includes parts of California, Nevada, Oregon, and Washington contains only small deposits of subbituminous coal. Only Washington produced any coal in 1970 and its production amounted to 0.06 million tons, of which 9 percent was strip mined.

Alaska has reserves of bituminous and subbituminous coal and lignite, but as yet there has been little demand for development of this resource. In 1970, 0.83 million tons of coal was produced by strip mining.

## Type of Mining

Of the Nation's total bituminous coal and lignite production in 1970, deep mining accounted for 61 percent. Strip mining yielded 36 percent, while auger mining produced 3 percent. Ninety-seven percent of the deep-mined coal, 86 percent of the strip-mined coal and virtually all of the auger-mined coal was produced east of the Mississippi River in 1970. The percent of coal produced in each State by strip mining is shown in figure 6.

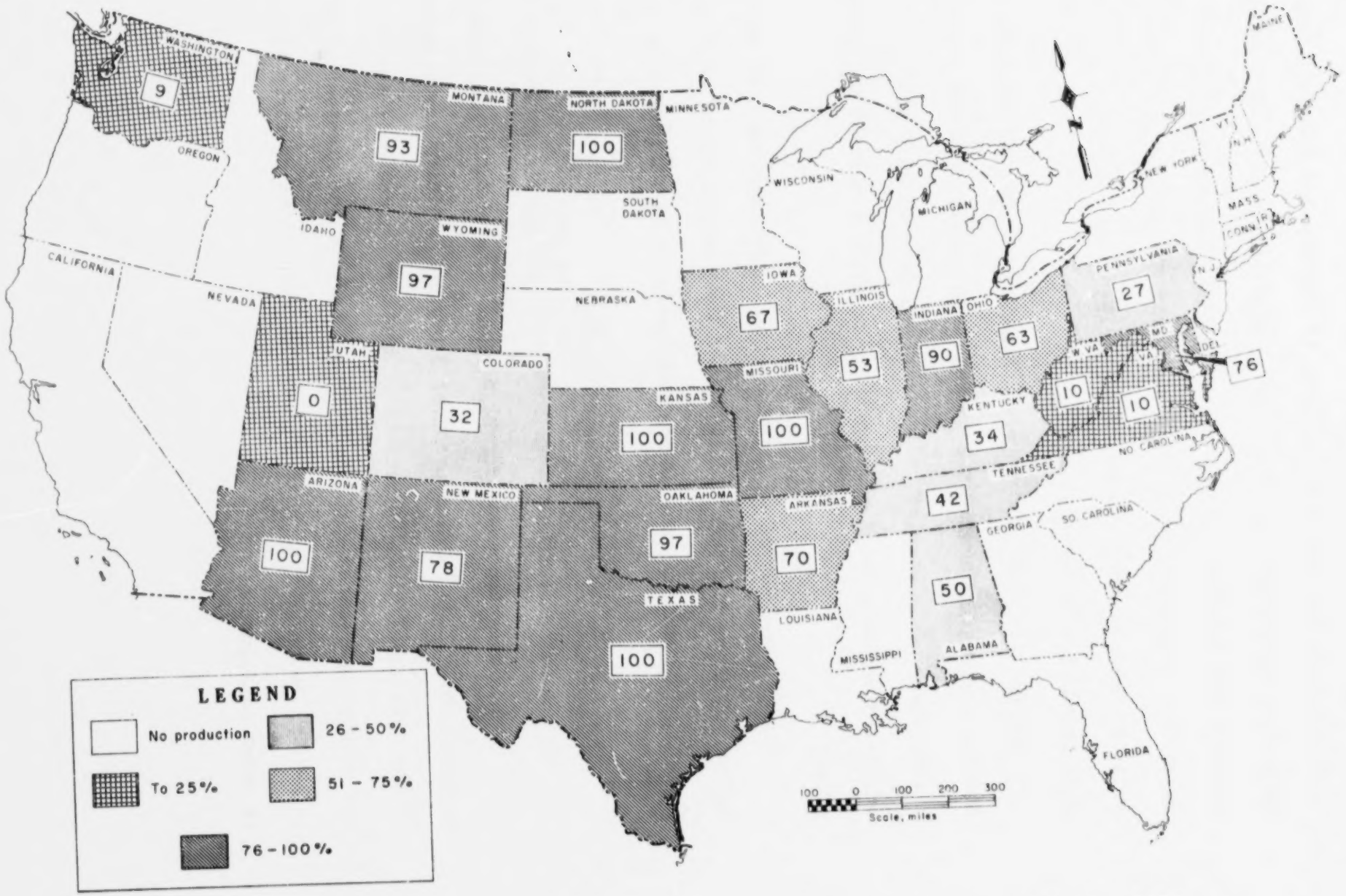



FIGURE 6. - Percent of bituminous coal and lignite mined by stripping, by State, 1970.

## Sulfur Content

Average sulfur content based on analytical records is shown for each State in table 8. These data indicate that analyses of coals sampled from Iowa, Kansas, Kentucky west, Missouri, and Ohio average 3 percent sulfur or more on the as-received basis. Analyses of coals sampled from Illinois, Indiana, Oklahoma, and Texas average between 2.0 and 2.8 percent sulfur. One of the two largest groups has coal sample analyses averaging between 1.1 and 1.9 percent sulfur and includes Alabama, Georgia, Idaho, Kentucky east, Maryland, Michigan, Montana, Nevada, Pennsylvania, Tennessee, and West Virginia. The second group with coal sample analyses averaging between 0.2 and 0.9 percent sulfur includes Alaska, Arizona, Colorado, New Mexico, North Dakota, Oregon, South Dakota, Utah, Virginia, Washington, and Wyoming.

## Ash Content

The average ash content of coals sampled from the various States on the as-received and dry basis is shown in table 8. Ash content ranges from 5.2 percent to 37.2 percent.

## Heating Value

Most of the as-received analyses of coals sampled from the coal producing States east of the Mississippi River have average heating values greater than 13,000 Btu per pound (table 8). Of the producing States west of the River only Oklahoma has an average value as-received of over 13,000 Btu per pound.

TABLE 8. - Average analysis of coals by State [1]

| STATE | MOISTURE | | | ASH | | | SULFUR | | | B.t.u. | | | NO. OF ANAL. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A.R.[2] | DRY[3] | M.&A.F.[4] | A.R.[2] | DRY[3] | M.&A.F.[4] | A.R.[2] | DRY[3] | M.&A.F.[4] | A.R.[2] | DRY[3] | M.&A.F.[4] | |
| Alabama | 3.4 | --- | --- | 7.7 | 8.0 | --- | 1.1 | 1.1 | 1.2 | 13370 | 13840 | 15040 | 1699 |
| Alaska | 16.8 | --- | --- | 10.1 | 13.2 | --- | 0.2 | 0.3 | 0.3 | 9560 | 11490 | 13250 | 153 |
| Arizona | 11.5 | --- | --- | 14.3 | 16.2 | --- | 0.9 | 1.0 | 1.2 | 10130 | 11450 | 13650 | 25 |
| Colorado | 9.9 | --- | --- | 7.7 | 8.6 | --- | 0.6 | 0.7 | 0.8 | 11510 | 12780 | 14000 | 3541 |
| Georgia | 2.8 | --- | --- | 10.5 | 10.8 | --- | 1.7 | 1.7 | 1.9 | 13460 | 13850 | 15520 | 25 |
| Idaho | 6.3 | --- | --- | 5.9 | 6.3 | --- | 1.1 | 1.2 | 1.3 | 12480 | 13320 | 14220 | 9 |
| Illinois | 10.9 | --- | --- | 9.6 | 10.8 | --- | 2.7 | 3.0 | 3.4 | 11400 | 12800 | 14340 | 3466 |
| Indiana | 11.7 | --- | --- | 8.8 | 10.0 | --- | 2.8 | 3.2 | 3.6 | 11490 | 13010 | 14450 | 1464 |
| Iowa | 15.8 | --- | --- | 13.4 | 15.9 | --- | 4.7 | 5.6 | 6.7 | 9900 | 11760 | 13980 | 337 |
| Kansas | 4.8 | --- | --- | 11.0 | 11.6 | --- | 3.3 | 3.5 | 4.0 | 12510 | 13140 | 14860 | 502 |
| Kentucky East | 4.1 | --- | --- | 6.2 | 6.5 | --- | 1.1 | 1.1 | 1.2 | 13400 | 13970 | 14950 | 2788 |
| Kentucky West | 7.6 | --- | --- | 8.6 | 9.3 | --- | 3.2 | 3.5 | 3.9 | 12160 | 13160 | 14500 | 2321 |
| Maryland | 2.8 | --- | --- | 10.2 | 10.5 | --- | 1.7 | 1.7 | 1.9 | 13520 | 13910 | 15540 | 385 |
| Michigan | 13.3 | --- | --- | 8.4 | 9.7 | --- | 1.7 | 2.0 | 2.2 | 11400 | 13150 | 14560 | 52 |
| Missouri | 10.0 | --- | --- | 11.3 | 12.5 | --- | 4.1 | 4.5 | 5.1 | 11390 | 12650 | 14460 | 619 |
| Montana | 13.7 | --- | --- | 9.8 | 11.3 | --- | 1.3 | 1.5 | 1.7 | 10280 | 11910 | 13430 | 440 |
| Nevada | 3.0 | --- | --- | 37.2 | 38.3 | --- | 1.4 | 1.4 | 2.3 | 8860 | 9130 | 14770 | 4 |
| New Mexico | 8.0 | --- | --- | 10.4 | 11.3 | --- | 0.7 | 0.8 | 0.9 | 11730 | 12750 | 14380 | 898 |
| North Dakota | 36.6 | --- | --- | 7.3 | 11.5 | --- | 0.6 | 1.0 | 1.1 | 6830 | 10770 | 12170 | 765 |
| Ohio | 6.3 | --- | --- | 9.3 | 9.9 | --- | 3.0 | 3.2 | 3.6 | 12250 | 13070 | 14510 | 2320 |
| Oklahoma | 4.6 | --- | --- | 8.1 | 8.5 | --- | 2.1 | 2.2 | 2.4 | 13050 | 13680 | 14950 | 891 |
| Oregon | 18.9 | --- | --- | 9.8 | 12.2 | --- | 0.6 | 0.7 | 0.8 | 9090 | 11210 | 12750 | 8 |
| Pennsylvania (Anth.) | 4.8 | --- | --- | 11.3 | 11.9 | --- | 0.7 | 0.7 | 0.8 | 12520 | 13150 | 14930 | 5852 |
| Pennsylvania (Bit.) | 3.3 | --- | --- | 10.0 | 10.3 | --- | 1.9 | 2.0 | 2.2 | 13270 | 13720 | 15280 | 5277 |
| South Dakota | 35.1 | --- | --- | 8.0 | 12.3 | --- | 0.6 | 1.0 | 1.1 | 7040 | 10840 | 12360 | 27 |
| Tennessee | 3.0 | --- | --- | 8.4 | 8.7 | --- | 1.4 | 1.4 | 1.5 | 13310 | 13720 | 15020 | 1210 |
| Texas | 9.0 | --- | --- | 11.2 | 12.3 | --- | 2.0 | 2.2 | 2.5 | 11330 | 12450 | 14190 | 33 |
| Utah | 5.4 | --- | --- | 6.9 | 7.3 | --- | 0.8 | 0.8 | 0.9 | 12610 | 13330 | 14380 | 1959 |
| Virginia | 2.7 | --- | --- | 7.7 | 7.9 | --- | 0.8 | 0.8 | 0.9 | 13850 | 14230 | 15450 | 1975 |
| Washington | 10.7 | --- | --- | 12.9 | 14.4 | --- | 0.6 | 0.7 | 0.8 | 10740 | 12030 | 14050 | 562 |
| West Virginia | 3.1 | --- | --- | 7.4 | 7.6 | --- | 1.4 | 1.4 | 1.5 | 13690 | 14130 | 15290 | 10382 |
| Wyoming | 14.6 | --- | --- | 5.2 | 6.1 | --- | 0.7 | 0.8 | 0.9 | 10850 | 12700 | 13530 | 1426 |
| Total U.S. | 6.4 | --- | --- | 8.7 | 9.3 | --- | 1.6 | 1.7 | 1.9 | 12530 | 13390 | 14760 | 51415 |

1/ Averages are based on number of analyses and not weighted by either rank or production and therefore should be used with caution.
2/ As-received condition represents the sample as received at the laboratory.
3/ The moisture-free (Dry) condition represents the composition and heating value of the dry coal
4/ The moisture- and ash-free condition represents approximately the composition and heating value of the dry combustible matter.

## Consumption

Figure 7 indicates consumption of bituminous coal and lignite in 1970. Consumption was greatest in Ohio and Pennsylvania, where more than 60 million tons of coal was consumed in each. Between 26 and 50 million tons were consumed each in Michigan, Indiana, Illinois, and in Mississippi and Alabama combined. Over 24 million tons were consumed in West Virginia. Consumption in New York, Virginia, North Carolina, Kentucky, Tennessee, Missouri, and Wisconsin was between 11 and 25 million tons each. Georgia and Florida combined consumed 13.2 million tons and the combination of Maryland and Delaware accounted for an additional 13.9 million tons. The other 24 States consumed less than 5 million tons each. The heavily-populated West Coast consumed relatively little coal.

## Pennsylvania Anthracite

Underground mining accounted for 18 percent of the anthracite production in 1970; strip production accounted for 50 percent, 32 percent was culm bank coal, and the remainder was dredge production (table 9).

Production of anthracite reached a peak output of 100 million tons in 1917. Production has decreased steadily since that time (figure 8). Productivity during the 1946-65 period increased from 2.84 to 6.55 tons per man-day, with most of the increase due to strip mining. However, in recent years, strip mining sites with shallow overburden have been virtually exhausted; mining costs are increasing as the stripping operations follow the coalbeds to greater depths.

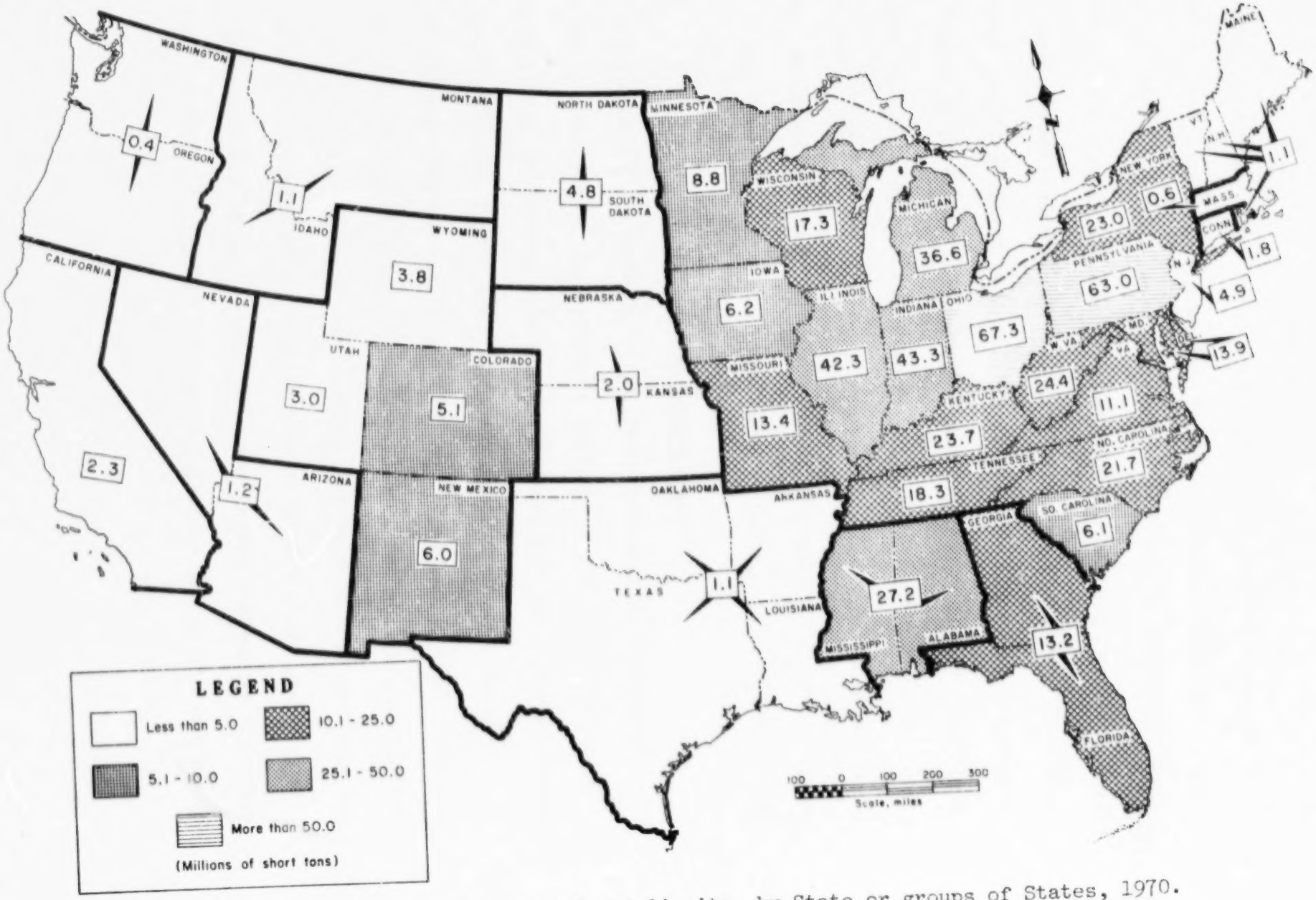


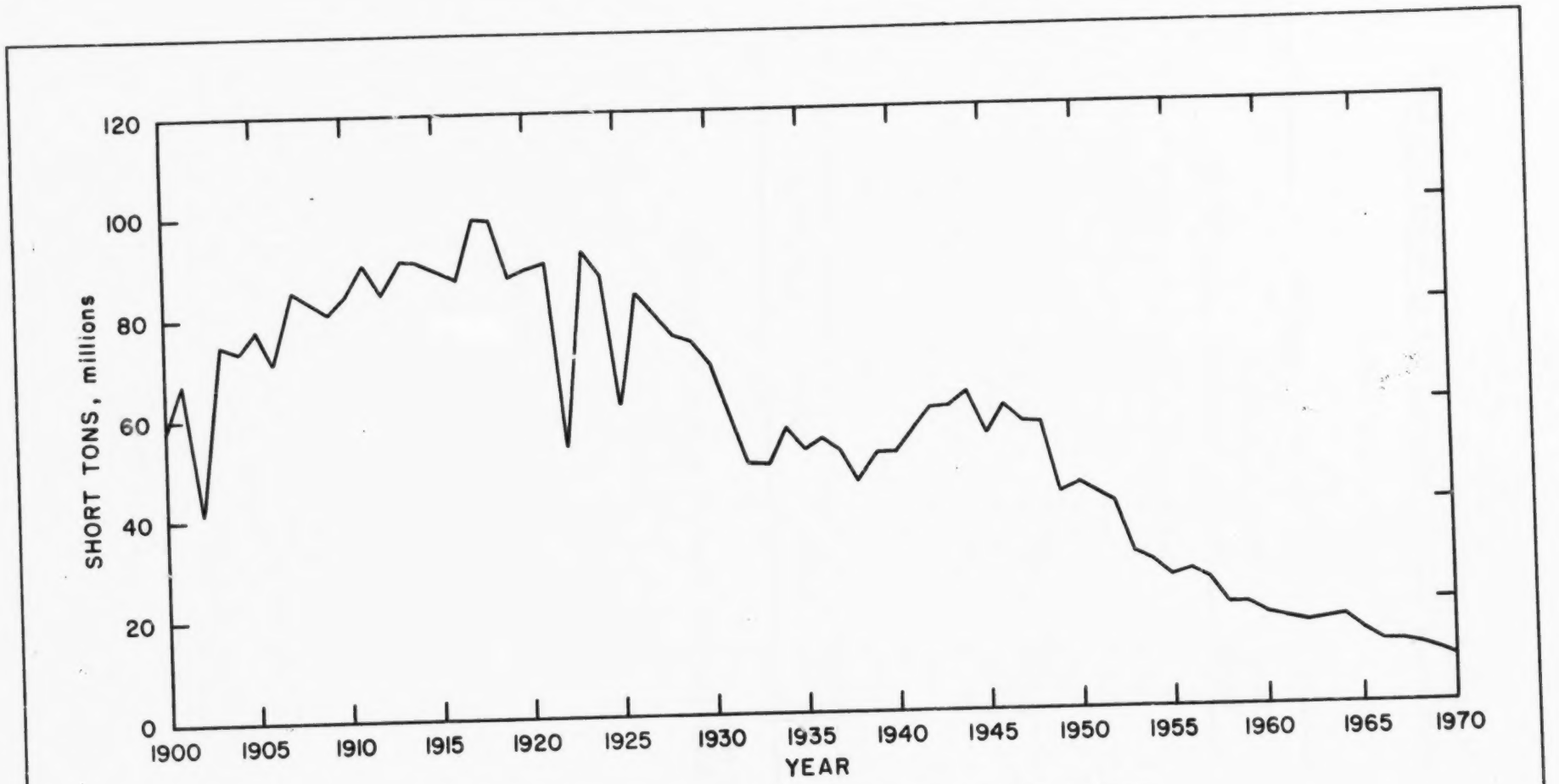

FIGURE 7. - Consumption of bituminous coal and lignite, by State or groups of States, 1970.

TABLE 9. - Anthracite production in Pennsylvania in 1970, by county, by type of mining, and by sulfur content

(Thousand tons)

| County | Deep mines | Strip mines | Culm bank mines | Total | Average sulfur content 1/ |
|---|---|---|---|---|---|
| Carbon | 21.5 | 258.0 | 179.9 | 459.4 | 0.5 |
| Columbia | 28.2 | 285.6 | 0.6 | 314.4 | 0.6 |
| Dauphin | 13.2 | --- | 28.9 | 42.1 | 0.6 |
| Lebanon | --- | --- | --- | --- | --- |
| Lackawanna | 0.01 | 248.8 | 165.0 | 413.8 | 0.7 |
| Luzerne | 625.1 | 1,543.1 | 853.8 | 3,022.0 | 0.7 |
| Northumberland | 228.7 | 331.7 | 584.7 | 1,145.1 | 0.8 |
| Schuylkill | 740.9 | 1,902.4 | 1,079.5 | 3,722.8 | 0.6 |
| Sullivan | --- | 36.9 | 0.6 | 37.5 | 0.6 |
| Susquehanna | --- | --- | 0.9 | 0.9 | 0.6 |
| Wayne | --- | --- | --- | --- | --- |
| Total | 1,657.6 | 4,606.5 | 2,893.9 | 2/9,158.0 | 0.7 |

1/ Weighted average.
2/ Does not include 323,000 tons of dredge production.




**Anthracite Production of Pennsylvania 1900-1970**

Adapted from Historical Statistics of Pennsylvania's Mineral Industries, 1759-1955 Bulletin of the Mineral Industries Experiment Station 69, March 1957.

FIGURE 8. - Anthracite production of Pennsylvania, 1900-1970.

Analyses of Pennsylvania anthracite on an as-received basis shows the following average values:

| | |
|---|---|
| Sulfur | 0.7 percent |
| Ash | 11.3 percent |
| Btu | 12,520 per lb. |

### Consumption

Space heating is the principal market for anthracite, consuming about 40 percent of production. The second largest market is electric utilities, 18 percent; followed by the iron and steel industry, 11 percent; U.S. Armed Forces, 10 percent; and exports, 6 percent. The remaining 15 percent was consumed by other industrial users, including ceramic plants, cement plants, and tobacco and hay curing plants; production of carbon for telephones, water and chemical filters, and purifiers; and for other electrical equipment.

## POTENTIAL FOR EXPANDED PRODUCTION

In forecasting coal production to 1976, the variables which may have the greatest impact on future expansion of the industry cannot be historically analyzed in a regression equation format, because they are recent in nature. Each significant variable which may have any constraint on the expansion possibilities of the coal market is discussed and analyzed to ascertain what effect the variable may have on coal production.

## Methodology

The following methodology was used in projecting the production by the coal industry, by State, through 1976 (table 10).

A. A 10-year time series (1960-69) was used with the least square equation, $y = a + bx$, to estimate 1976 coal production by State, except for Arizona which had no significant production prior to 1970. Arizona's projected production is based on reported plans of the Peabody Coal Company (3)[1/].

B. In projecting the amount of 1 percent or less sulfur coal, it was assumed the same ratio which existed between coal with 1 percent or less sulfur and total coal in 1964 would prevail in 1976, except for Pennsylvania. The pro rata distribution of production by sulfur content for Pennsylvania was based on the reported sulfur levels included in the report "Analysis of the Availability of Bituminous Coal, Appalachian Region." This projected ratio is probably biased low for 1 percent or less sulfur coal since lower sulfur coal will probably be a premium product in 1976 and will probably be selected over high sulfur coal products for increased production.

C. The time series projections were modified when the projection did not reflect a reasonable emperical approximation of future conditions which may exist in the coal market.

## Constraints, Economic Strategics, and Legislation

The constraints which affect forecasting coal production can generally be divided into exogenous and endogenous variables.

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1/ Underlined numbers in parentheses refer to items in the list of references at the end of this report.

TABLE 10. - Projected bituminous coal and lignite production in the United States, by State and sulfur content to year 1976

(Thousand tons)

| State | Total coal production | | Coal production <1.0 percent sulfur | | Coal production 1.0 to 2.0 percent sulfur | | Coal production 2.1 percent or more sulfur | |
|---|---|---|---|---|---|---|---|---|
| | 1970 | 1976 | 1970 | 1976 | 1970 | 1976 | 1970 | 1976 |
| Alabama | 19,500 | 22,322 | 11,993 | 13,728 | 7,507 | 8,594 | --- | --- |
| Alaska | 830 | 786 | 830 | 786 | --- | --- | --- | --- |
| Arizona | 280 | 1/13,000 | 280 | 13,000 | --- | --- | --- | --- |
| Arkansas | 385 | 231 | --- | --- | 177 | 107 | 208 | 124 |
| Colorado | 5,830 | 7,767 | 5,830 | 7,767 | --- | --- | --- | --- |
| Illinois | 64,730 | 82,008 | --- | --- | 19,484 | 24,684 | 45,246 | 57,324 |
| Indiana | 20,990 | 24,436 | 168 | 195 | 4,996 | 5,816 | 15,826 | 18,425 |
| Iowa | 1,065 | 856 | --- | --- | --- | --- | 1,065 | 856 |
| Kansas | 2,030 | 2,174 | --- | --- | 10 | 12 | 2,020 | 2,162 |
| Kentucky, East | 68,967 | 87,225 | 62,001 | 78,415 | 6,483 | 8,199 | 483 | 611 |
| Kentucky, West | 53,163 | 66,152 | --- | --- | 266 | 331 | 52,897 | 65,821 |
| Maryland | 1,755 | 2,157 | 135 | 166 | 507 | 623 | 1,113 | 1,368 |
| Missouri | 2,800 | 3,437 | --- | --- | --- | --- | 2,800 | 3,437 |
| Montana | 1,740 | 1,726 | 1,740 | 1,726 | --- | --- | --- | --- |
| New Mexico | 5,600 | 8,092 | 5,600 | 8,092 | --- | --- | --- | --- |
| North Dakota | 4,900 | 6,631 | 4,876 | 6,598 | 24 | 33 | --- | --- |
| Ohio | 51,585 | 66,330 | --- | --- | 5,313 | 6,832 | 46,272 | 59,498 |
| Oklahoma | 2,520 | 2,403 | 1,031 | 983 | 678 | 646 | 811 | 774 |
| Pennsylvania | 81,280 | 94,045 | 10,810 | 12,508 | 46,492 | 53,794 | 23,978 | 27,743 |
| Tennessee | 8,935 | 10,263 | 2,278 | 2,617 | 3,431 | 3,941 | 3,226 | 3,705 |
| Utah | 4,852 | 4,460 | 4,794 | 4,407 | 24 | 22 | 34 | 31 |
| Virginia | 39,335 | 44,995 | 32,333 | 36,985 | 7,002 | 8,010 | --- | --- |
| Washington | 65 | --- | 65 | --- | --- | --- | --- | --- |
| West Virginia | 140,513 | 170,942 | 88,383 | 107,522 | 23,325 | 28,376 | 28,805 | 35,044 |
| Wyoming | 6,630 | 7,288 | 6,630 | 7,288 | --- | --- | --- | --- |
| Total | p/590,280 | 729,726 | p/239,777 | 302,783 | p/125,719 | 150,020 | p/224,784 | 276,923 |

1/ "Peabody Puts Arizona on the Coal Map," Coal Mining & Processing, v. 8, No. 2, 1971, pp. 30.

p/ Preliminary.

The major exogenous constraint which affects the coal market are restrictions regulating sulfur oxides emissions. A growing concern by the public has fostered new regulations. Severe air pollution regulations could restrict expansion possibilities for coal consumption. The degree of restriction on coal consumption may depend on the advances in coal preparation technology for the pre-combustion reduction of air pollution material. Likewise, improved technology for the post-combustion elimination of pollutants in stack emissions may also be a factor that will influence the possibilities for expanded production of coal. The effect of air pollution regulations on the production of coal will also depend on residual fuel oil importation and other competitive fuels. However, the continued availability of foreign low-sulfur residual fuel oil, depending on the stability of future international relations, and the availability of tankers, may have an adverse effect on the future production of coal.

If an effective sulfur oxides abatement process can be developed within a reasonable period of time, coal will maintain its share of the market and will probably experience some gains. If an effective abatement system for sulfur oxides is not developed in the near future, coal will more than likely decrease substantially in its share of the energy market.

Laws regulating sulfur oxides pollution have substantially different economic effects on coal marketing areas. If pre-combustion regulations of 1 percent sulfur content were invoked nationwide, most, if not all of the coal from Illinois, Indiana, eastern Ohio, and western Kentucky would

be unusable, and therefore the straight line projections in table 10 will be too high. The lower-sulfur coals (1 percent or less) of Alabama, eastern Kentucky, Pennsylvania, Tennessee, Virginia, and West Virginia would realize increases in demand. Those coals that can be washed to 1 percent or less sulfur would also increase in demand. The overall effect might be a decrease in the total supply of coal for the period 1970 to 1976.

An adequate supply of low-sulfur coal is available in the western States. In the eastern States where most of the high-sulfur coal exists, the blending of coal could reduce the sulfur content somewhat, but would not be a long term solution. Most of the coal produced in the eastern States exceeds 1 percent sulfur, and blending is not an economically feasible way to reduce the sulfur content of these coals.

It has been suggested that metallurgical coal be used to supplement the supply of coal to steam plants. This would not be a feasible alternative in Appalachia because a significant amount of the coal used for coking and export is already above the 1 percent sulfur level. Table 11 shows reported exports of 24 million tons of coal with an average sulfur content of 1.0 percent. Exported coal ranged in sulfur content from 0.5 to 3.0 percent. Included in the exported tonnage was some coal destined for Canadian consumption.

The improvement of washing plant efficiency would reduce the sulfur content of some coals; the amount that could be washed to an acceptable level is unknown. However, most coals produced in eastern United States today could not be economically washed to a 1 percent sulfur level.

TABLE 11. - Reported consumer uses of coal by weighted average sulfur content, produced by selected companies, Appalachian Region, 1967

(Thousand short tons)

| State | Utilities | | | Coke | | | Industrial and retail | | | Export | | | Other | | | Total 1/ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Quantity | Sulfur range | Average sulfur | Quantity | Sulfur range | Average sulfur | Quantity | Sulfur range | Average sulfur | Quantity | Sulfur range | Average sulfur | Quantity | Sulfur range | Average sulfur | Quantity | Average sulfur |
| Ala. | 5,823 | 0.7 - 2.3 | 1.5 | 4,199 | 0.6 - 1.5 | 1.0 | 1,393 | 0.9 - 1.4 | 1.3 | - | - | - | - | - | - | 11,417 | 1.3 |
| Ky.-East | 10,140 | 0.5 - 4.0 | 1.3 | 6,963 | 0.5 - 1.4 | 0.6 | 5,684 | 0.5 - 2.0 | 0.9 | W | 0.5 - 0.9 | 0.6 | W | 0.5 - 1.3 | 0.7 | 23,437 | 1.0 |
| Md. | 486 | 2.5 - 3.3 | 2.7 | - | - | - | 135 | 3.0 | 3.0 | - | - | - | 20 | 3.0 | 3.0 | 641 | 2.8 |
| Ohio | 26,681 | 1.7 - 5.5 | 3.7 | (2) | 1.4 - 2.8 | 1.8 | 7,724 | 1.4 - 5.0 | 3.4 | - | - | - | 3/1,043 | 2.5 - 4.6 | 3.6 | 35,449 | 3.7 |
| Pa.-Bit. | 20,000 | 0.8 - 4.6 | 2.4 | 27,721 | 0.9 - 3.5 | 1.3 | 6,162 | 0.2 - 3.7 | 1.9 | W | 1.0 - 3.0 | 1.7 | W | 1.0 - 3.5 | 2.2 | 56,511 | 1.8 |
| Tenn. | 2,345 | 1.0 - 4.0 | 2.1 | - | - | - | (2) | 1.0 - 3.3 | 1.3 | - | - | - | 4/680 | 0.7 | 0.7 | 3,026 | 1.9 |
| Va. | 7,572 | 0.5 - 6.0 | 1.0 | 6,152 | 0.5 - 0.9 | 0.6 | 1,831 | 0.5 - 6.0 | 1.1 | W | 0.5 - 2.0 | 0.8 | W | 0.5 - 1.5 | 0.8 | 20,197 | 0.9 |
| W. Va. | 43,682 | 0.5 - 4.2 | 2.3 | 36,077 | 0.5 - 3.3 | 0.8 | 15,453 | 0.5 - 4.2 | 1.4 | 17,700 | 0.5 - 3.0 | 1.0 | 2,320 | 0.4 - 3.3 | 1.2 | 115,232 | 1.5 |
| Total | 116,729 | | 2.4 | 5/81,112 | | 1.0 | 5/38,382 | | 1.8 | 24,115 | | 1.0 | 5,567 | | 1.7 | 265,910 | 1.8 |

W - Withheld to avoid disclosing individual company confidential data.
1/ Data may not add to totals shown because of independent rounding.
2/ Withheld to avoid disclosing individual company confidential data; included with "Other".
3/ Includes coke and other uses.
4/ Includes industrial, retail and other uses.
5/ Excludes data indicated by footnote 2/.

Source: Data obtained from a special canvass of coal producers of 100,000 tons or more in 1967.

Selective mining might be used to produce a lower-sulfur coal. The mining would be more expensive and significant coal reserves would be left in the ground and forever lost to mining.

There may be a substantial increase in demand by the western market for the low-sulfur coals of the western United States. The amount of coal mined in this area in 1970 was approximately 30 million tons. This coal probably will not serve the eastern coal markets to any extent in the foreseeable future because of the high cost of transportation, the lack of productive capacity in the western coalfields, and competition from residual fuel oil. However, in the event of coal gasification, a different set of economic conditions may prevail.

A major reason for the potential loss in market for coal is because of the availability of residual fuel oil of a quality to meet the sulfur content required in the several States. From 1959 through 1965, imports of residual fuel oil into the East Coast were limited by legislation to a percentage of demand. In 1966, the East Coast market was opened to unlimited imports of residual fuel oil resulting in a substantial part of the electric output becoming dependent on imports. This occurred because of the urgent need of the electric utility industry for a source of fuel which the domestic coal industry could not supply at the time.

In the interior of the country, controls on imported residual fuel oil continued until recently. The high cost of residual fuel oil transportation made the question of imports to the interior moot. With the demand for reduction of sulfur oxides emissions, utilities in the interior of the country have shown a tendency to switch to fuel oil

having a sulfur content commensurate with the respective State's requirements. Based on laid-down prices of a barrel of residual fuel oil on the Gulf Coast and the cost of barging to the midwest, imported 1 percent or less sulfur residual fuel oil costs utilities in the Midwest about 50 percent more than coal. Currently, one application for permission to import residual fuel oil into the Midwest was granted early in 1970; many others are pending.

If oil gains substantially in its share of the fuels market, it may be difficult for coal to regain its previous market position. Market-producer relationships will be firmly entrenched so that lead time and planning for new capacity would be lost. Switching back to coal would be economically difficult, even if an abatement system for sulfur oxides was developed.

Currently, new laws restricting strip mining operations are being discussed by legislative bodies. Laws probably will not be enacted that would eliminate strip mining, but reclamation laws may be enacted that could directly influence the cost of strip-produced coal.

The major endogenous constraints which may affect the expansion of production to supply the coal market are more fully discussed in the supplemental report "Restrictions on the Uses of Coal", June 1971. The more critical ones are:

(1) New mine safety laws

(2) Transportation infrastructure

(3) Capital and investment criteria

(4) Labor problems

The new Federal Coal Mine Health and Safety Act of 1969 may have a formidable effect on the productivity and expansion possibilities of the coal industry. The standards are some of the strictest ever enacted; many mines with existing technology may not be able to continue in operation. Generally, smaller mines will have more difficulty complying with the law than larger mines because they will have greater difficulty obtaining the necessary equipment and capital to operate. No definite effect can be ascribed to the Act because of lack of data due to the limited time the Act has been in effect.

Due to the many uncertainties existing in the coal industry today, further expansion becomes difficult because investors are unwilling to venture capital into an unsure market. Additionally, transportation facilities to support large coal operations in some areas may be in short supply through 1976. There may be a problem of an adequate supply of labor if the coal industry is to expand appreciably in the next decade. In the last 5 years (1966-70), the coal demand has grown such that no excess capacity exists as evidenced by the planned opening of new mines and the expansion of existing mines, according to the National Coal Policy Conference, Inc. The industry is having difficulty luring people, both professional and non-professional, because of the socio-logical concept of the work. Consequently, expansion becomes difficult even in areas where unemployment exists in the labor market.

## Pennsylvania Anthracite Production in 1976

Production of anthracite is expected to decline so that in 1976 the output may be only 4 million tons (table 12). If the trend since 1960 continues, there will be no production from deep mines and only 2.3 million tons from strip mines. The projected total production of anthracite to 1976 is 3.8 million tons. Assuming these projections to be valid, the difference of 1.5 million tons must derive from culm bank production. Because anthracite is expensive to produce, it seems probable that future production will be limited to the tonnage that may be consumed locally for residential heating. Air pollution regulations could be a favorable influence on the demand for anthracite because of its low-sulfur content, but the lack of efficient burning equipment probably will limit the demand. Homeowner's ideas on convenience and the reluctance of new-home builders to install coal-fired equipment in the face of cheaper, more convenient oil or gas fired equipment serves as a damper on expanded use of anthracite. Likewise, plant owners are hesitant to install the more expensive coal-burning equipment.

The electric utility market has been supplied mostly with anthracite recovered by dredging and from culm banks. This market may disappear as these sources become exhausted. Anthracite for the steel and cement industries has been relatively stable. Some increase in demand for sintering and pelletizing iron ore and for industrial carbon and metallurgical uses may be expected.

TABLE 12. - Potential for future anthracite production in Pennsylvania by year 1976 1/

(Million tons)

| State | Total coal | | | | Coal 1.0 percent sulfur or less | | | |
|---|---|---|---|---|---|---|---|---|
| | 1970 Production | | 1976 Production | | 1970 Production | | 1976 Production | |
| | Deep | Strip | Deep | Strip | Deep | Strip | Deep | Strip |
| Pennsylvania | 1.66 | 4.61 | (2) | 2.28 | 1.66 | 4.61 | (2) | 2.28 |

1/ 1976 production is based on past production. Does not include that production from culm banks or dredging. See methodology on page 29.

2/ Insignificant production.

Anthracite unit costs are the highest among the competitive fossil fuels due to unfavorable geologic conditions. The ready availability and convenience of alternative fuels in the past have substantially reduced the demand for anthracite. If the continuing downward trend in demand for anthracite in the energy markets is to be checked, new and improved technologies to increase production efficiency and reduce mining costs are necessary. Since anthracite is a clean, low sulfur energy source, increasing need and demand for such a fuel may provide the necessary incentive to develop the required technologies.

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15. Supplementary Notes

16. Abstracts

Data are compiled in this report on the total remaining coal resource of the United States, the production of coal in 1970 by mining method, sulfur content, ash content, and BTU value. Production of all coal has been projected to 1976. Projections have also been made in three sulfur categories: less than 1.0 percent, 1.0 to 2.0 percent, and 2.1 percent or more sulfur. The total remaining coal resource of the United States, as of December 31, 1970, is estimated at 1,576 billion tons, consisting of 693 billion tons of bituminous coal, 420 billion tons of subbituminous coal, 447 billion tons of lignite, and 16 billion tons of anthracite.

17. Key Words and Document Analysis. 17a. Descriptors

Coal
Resources
Reserves
Coal deposits
Coal mining
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